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MEMS Reliability for Space Applications by Elimination of Potential Failure Modes Through Testing and Analysis

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Micro-Electro-Mechanical (MEMS) devices have successfully been used in terrestrial applications for many years. Light-weight, low-cost, functionally-focused MEMS sensors and actuators promise to revolutionize space exploration in the next millennium. While the potential applications of MEMS are great, the utilization of MEMS technologies in NASA's space missions have been limited due to concerns of reliability and qualifiability of MEMS devices. Long term reliability and survivability of MEMS devices for space applications require effective ground demonstration of reliable and robust operation in the hostile environment of space since they cannot be brought back to Earth for service. The establishment of qualification requirements and guidelines has been made difficult in part due to many types of MEMS devices, with different sets of failure modes stemming from different fabrication and construction techniques.

This paper reviews some general approaches to addressing the reliability and qualification of different types of MEMS devices for space applications. The failure modes associated with different types of MEMS devices that are likely to occur, not only under normal terrestrial operations, but also those that are encountered in the harsh environments of space will be identified. Tests, analyses, and modeling activities that can be performed throughout the development cycle to mitigate those failure modes will be described. By understanding the failure modes and mechanisms under different operational environments, mitigation strategies could be developed throughout the development and fabrication processes to ensure reliable operation of the device during the intended mission.